Magnetism of Mercury

Most recent answer: 10/22/2007

Q:
Is mercury, on both an elemental and compound basis, a material that could be magnetized?
- Natalie
Florida, USA

A:
At room temperature, the element mercury is not very magnetic at all. It has a very small, negative magnetic susceptibility, meaning that when you put mercury in a magnetic field, it magnetizes just a little tiny bit in the opposite direction. We say that mercury is a weakly diamagnetic substance at room temperature.

Many compounds containing mercury are also weak diamagnets, but some are a little stronger than mercury itself. It probably is possible to make an alloy of iron and mercury which is magnetizable, but that wouldn't be the mercury's doing.

Mercury is much more interesting magnetically at very low temperatures. At temperatures below about 4 degrees Kelvin, elemental mercury becomes a superconductor. In fact, superconductivity was discovered by Kamerlingh Onnes in 1911 by studying mercury at low temperatures.

Superconductors generally expel magnetic fields, so you could say that below 4 K, mercury is a perfect diamagnet. To expel a magnetic field from a material, a canceling field must be created by that material with currents flowing on the surface. These currents flow with no resistance in superconductors.

You can also make a permanent magnet out of a loop of superconducting mercury. Simply cool down a loop of mercury in an external magnetic field (the temperature at which the mercury will superconduct will get lower as the applied field gets stronger). After the mercury becomes superconducting, it locks in the total magnetic flux through the loop. Switch off the external magnetic field, and a persistent current will flow around the mercury loop, making a permanent magnetic field.

Tom J.

(published on 10/22/2007)

Follow-Up #1: When superconducting magnets go normal

Q:
When u make a permanent magnet out of mercury at below 4 kelvin. what happens to the mercury and the magnetic field, when the mercury is brought up in temperature? would like to know TY for your time and great answers.
- Bruce W. (age 28)
Clearlake Califonia USA

A:
As that superconducting current loop warms up, it will switch to the normal state, which has electrical resistance. The current will rapidly run down, and the magnetic field will go away. As the field rapidly changes, a pulse of electromagnetic radiation will propagate outward. The mercury will also pick up some extra heat.

I think that pretty much covers it.

Mike W.

(published on 07/21/2012)

Follow-Up #2: cooling superconductor in field

Q:
If the mercury was super cooled right after the moment of release of field, would it recapture the field? If it was the nearest metal object? Ty again and sorry can't stop the gears in my head.
- Bruce W. (age 28)
Clearlake Ca USA

A:
This doesn't really sound like something that could happen. Remember that the mercury won't go normal until the temperature reaches the transition temperature (which is slightly lowered by the presence of the field and the current). Once the mercury goes normal, there's a burst of heating from the current flowing through the resistance, so the mercury goes well above the transition temperature. I can't think of any way to actually re-cool the mercury until the field that it had is gone.

Now an exception comes up if there's something else trapping the field in the region of the mercury. An external superconducting cylinder would be one example. Then re-cooling the mercury will capture some field again. The field inside the mercury ring will go up just slightly, because the field that had penetrated the mercury will partly be pushed inside the ring and partly outside the ring.

Mike W.

(published on 07/23/2012)

Follow-Up #3: magnetic panning for gold with mercury

Q:
I've been panning gold for a few years and much of my gold has mercury on it. I recently got a rare earth magnet about 60Lb or 80 I forget the Lb but I read that mercury is magnetic and that it switchs on and off depending on where the nutrons and protrons and all are as they spin around. When they come close they switch on and as they sepperat off. So I took my magnet and with the mercury coated gold in a glas vial filled with water i started swipeing it along the gold and it did pull all of the coated gold from one end of the vial to the other. Not like a really stron pull but stron enought it only took about 10 swipes to move all of it from one end to the other of the vial. A second vial of my clean gold I keep sepperat from the gold with mercury coating I did same test to see if maybe it was not the mercury but another metal mixed in with the gold. I could not get a single speck of the uncoated gold to move.
- Robert Way (age 55)
Greensboro NC

A:
Both mercury and gold are very weakly diamagnetic, i.e. repelled by magnetic fields. This effect might in principle let you push them ahead of the field, but it is almost certainly too weak to work in practice. You say the particles were "pulled", which would not fit this picture.

Now there's another possible mechanism. Gold and mercury are conductors. That means that changing magnetic fields stir up eddy currents in them. That gives them temporary magnetic moments. If this is how you're moving them, I'd predict that if you tried moving the magnet slowly, it wouldn't work, since it's the rate of change of the field that counts.

But why would nothing happen without the mercury? Two reasons:
1. The mercury helps form bigger blobs of conducting metal, allowing for more eddy currents.
2. The mercury can lubricate things, reducing friction.

Try the slow-motion experiment and let us know how it comes out.

Mike W.

(published on 10/16/2012)

Follow-Up #4: superconducting levitation

Q:
Ok i know that i'm going to sound like an antigravity theorist or someone that watched the movie "Contact" one too many times but I am really curious as to what would happen if you put liquid mercury inside a gyroscope made of conductive metal, lowered the temp below 4k, added an electrical current to each ring (creating a magnetic field in each i think) and then spun each ring in a different direction. both on a large and small scale. sorry if this is a ridiculous question.
- derek (age 36)
cornelius oregon USA

A:
It's hard to follow the description of where the currents are flowing, but we can answer your more general question. Mercury will go superconducting when it's cold enough, and superconductors can be used to levitate magnets or other superconductors.

Mike W.